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GB 1594559 A

WO 93/23890 A1

US 5178722 A

US 4291312 A

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(54) Antenna assembly

(57) An antenna assembly comprises an antenna 15 mounted on a sheet of dielectric material 11. The dielectric sheet 11 carries an electrically conductive layer 16 which extends around the antenna 15, with the electrically conductive layer 16 being suitable for reducing surface wave propagation in the sheet. Preferred features relating to the pattern, thickness and resistance of the conductive layer 16 are disclosed. The dielectric material 11 may be laminated glass and the conductive layer 16 may be a perforated translucent coating or film. The antenna 15 may be a laminar microwave patch. Also disclosed is a sheet of translucent dielectric material 11 which carries an electrically conductive coating 16 arranged around a location suitable for mounting an antenna 15. The electrically conductive coating 16 being suitable for reducing wave propagation in the sheet.

Fig.1.

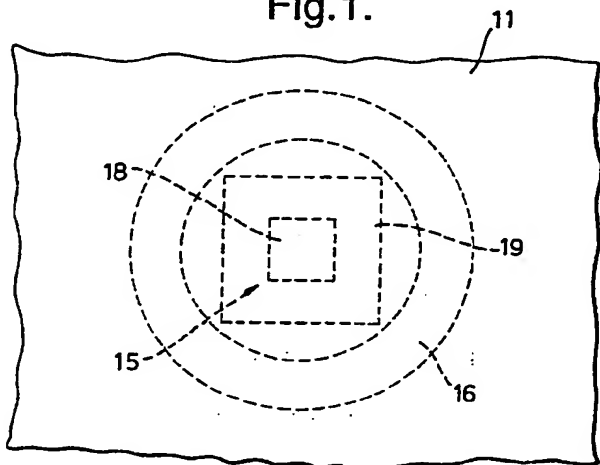
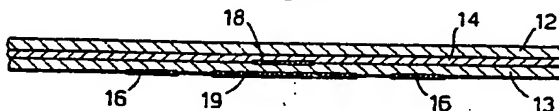


Fig.2.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

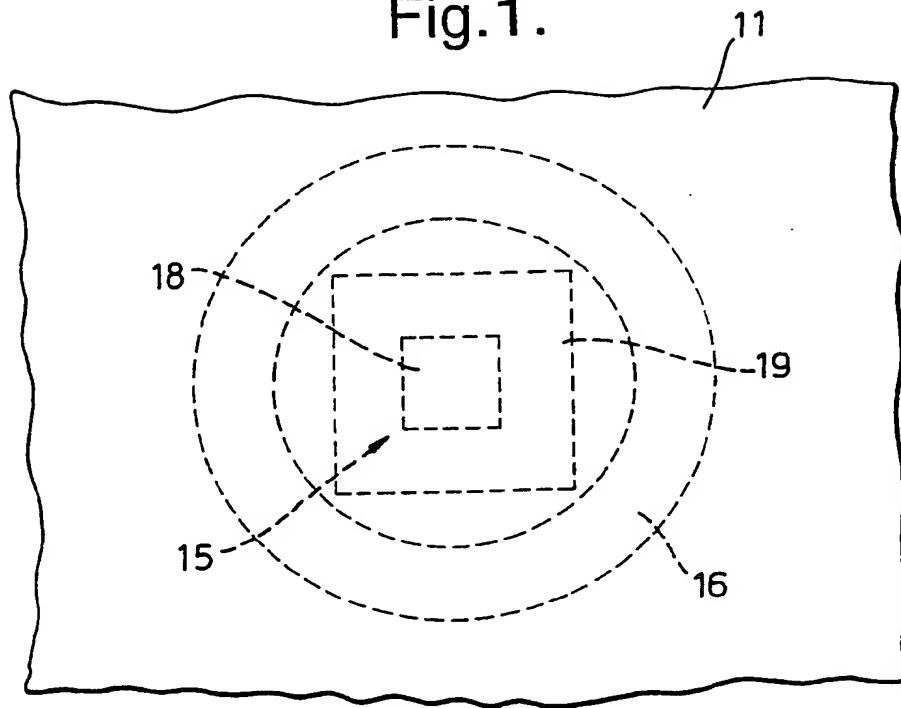


Fig.2.

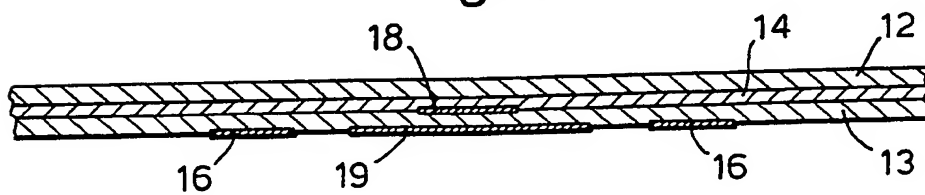


Fig.3.

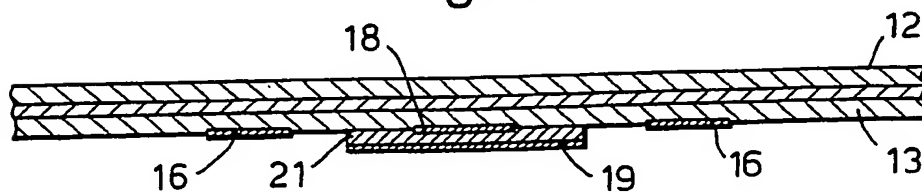


Fig.4.

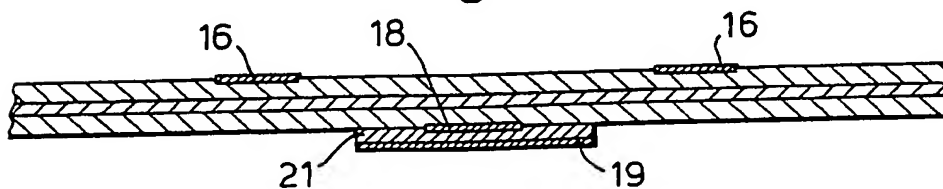


Fig.5.

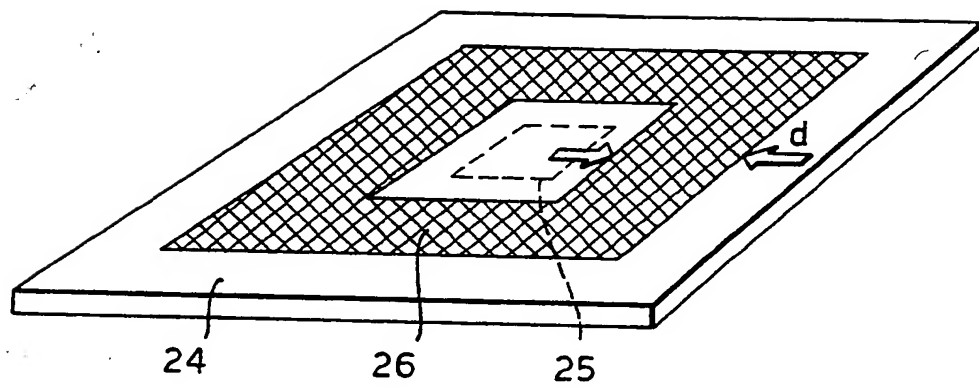
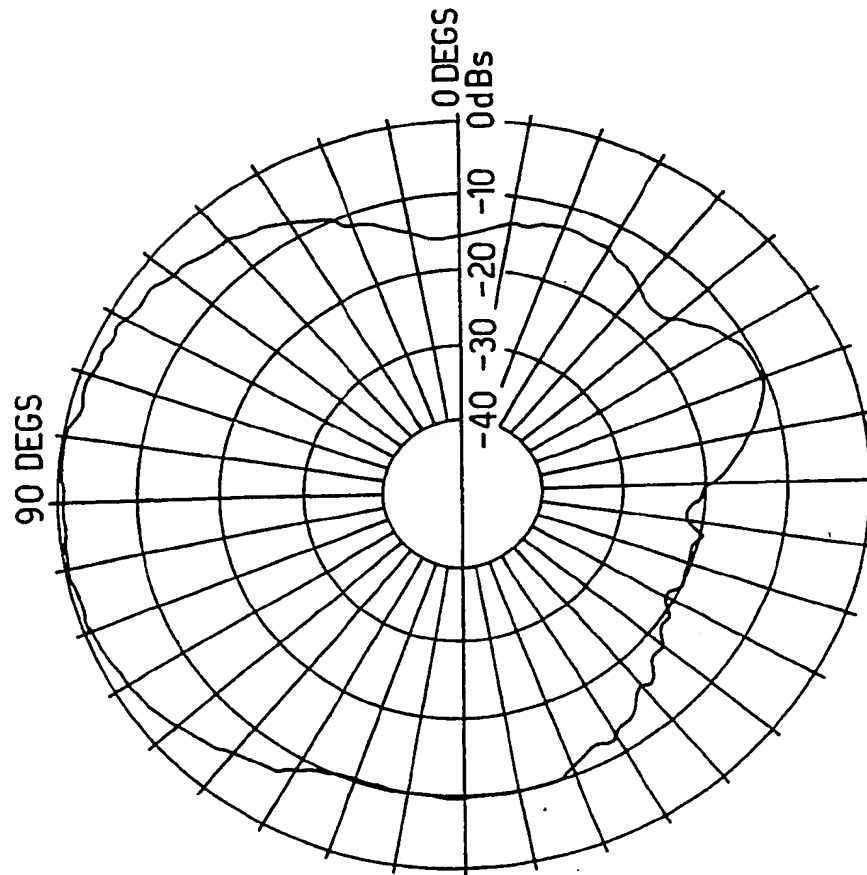
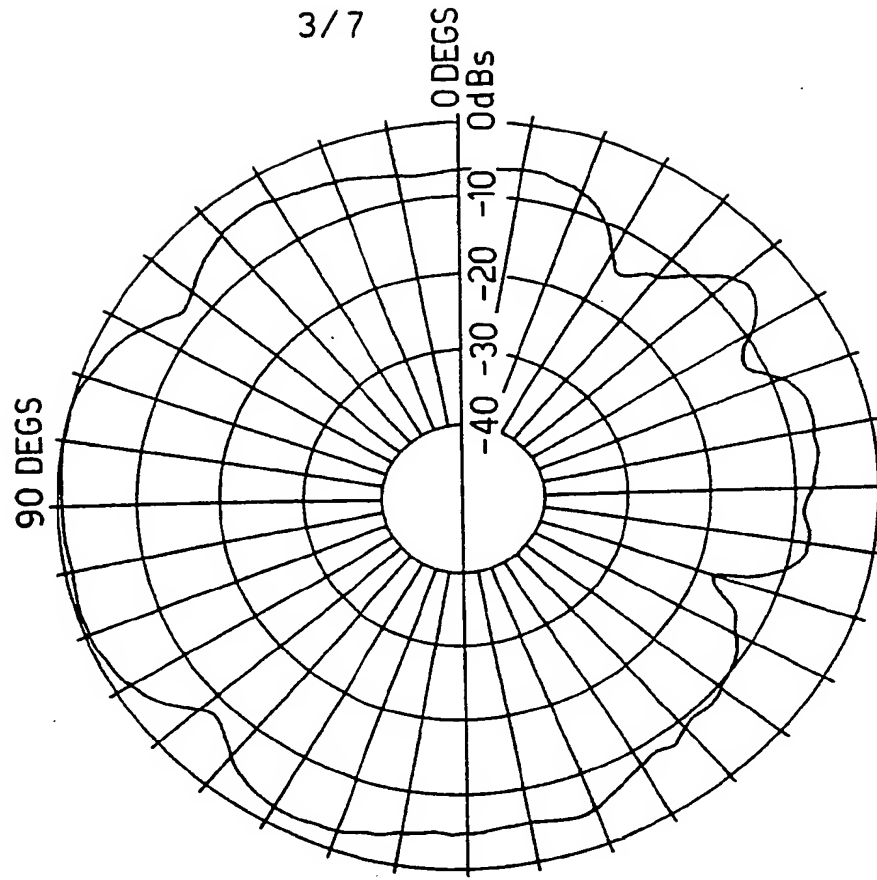


Fig.6.



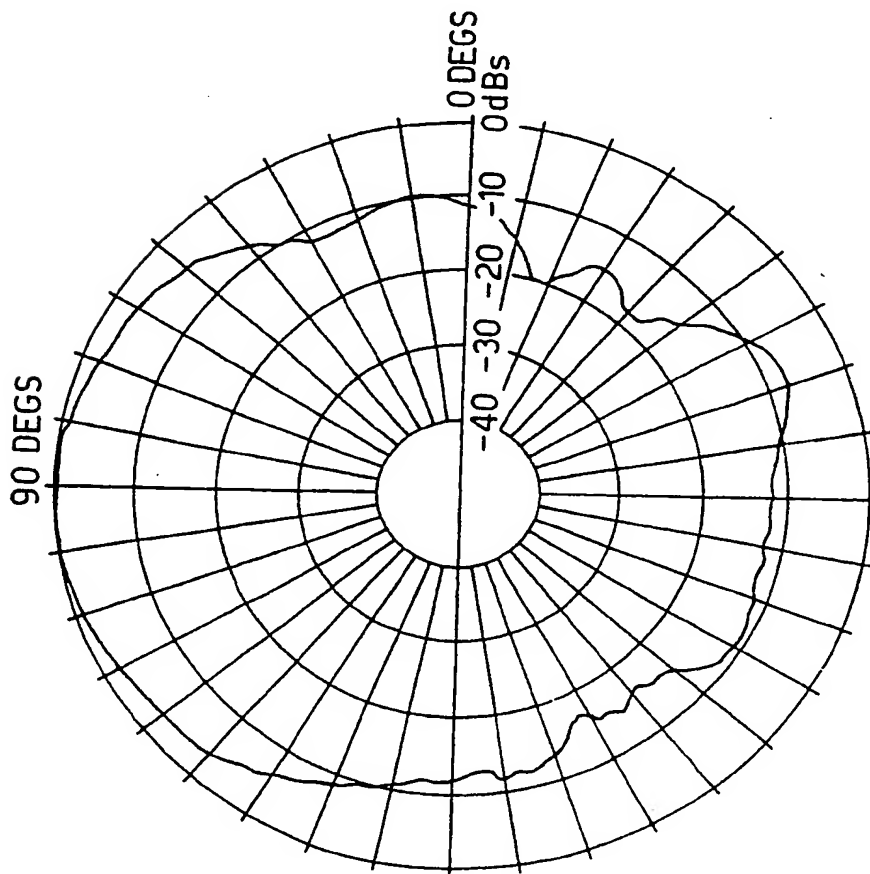
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Fig.7.



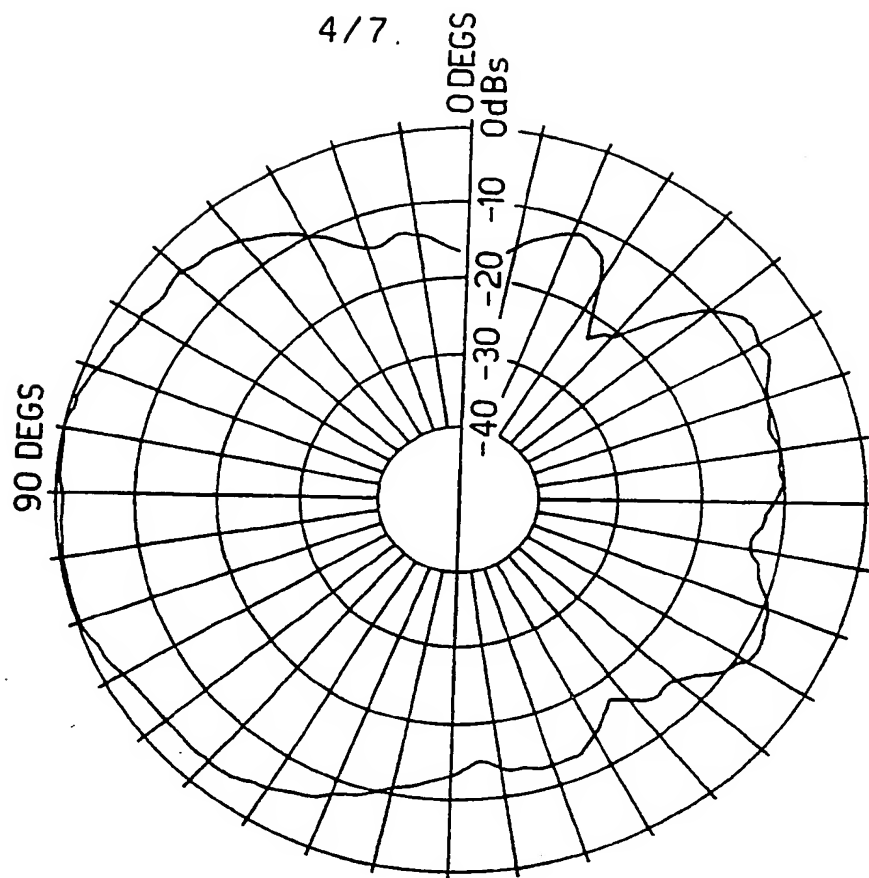
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NORMAL ANGLE = 90 DEGS

Fig.8.



REFERENCE LEVEL = -45.22 dBs
NORMAL ANGLE = 90 DEGS

Fig.9.



REFERENCE LEVEL = -44.57 dBs
NORMAL ANGLE = 90 DEGS

Fig.10.

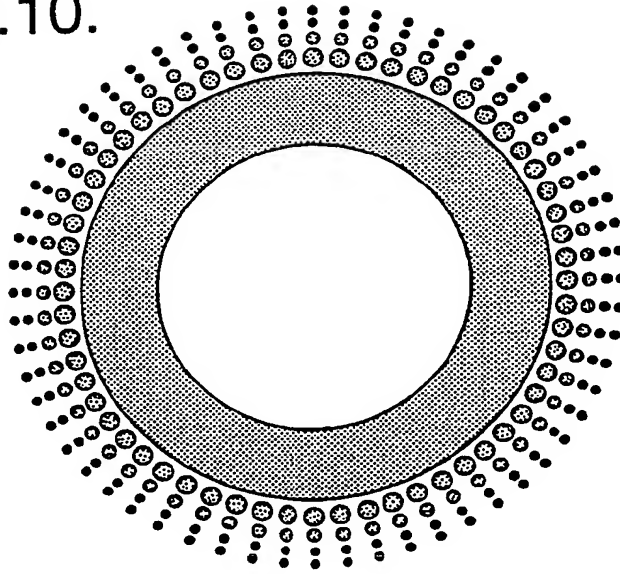


Fig.11.

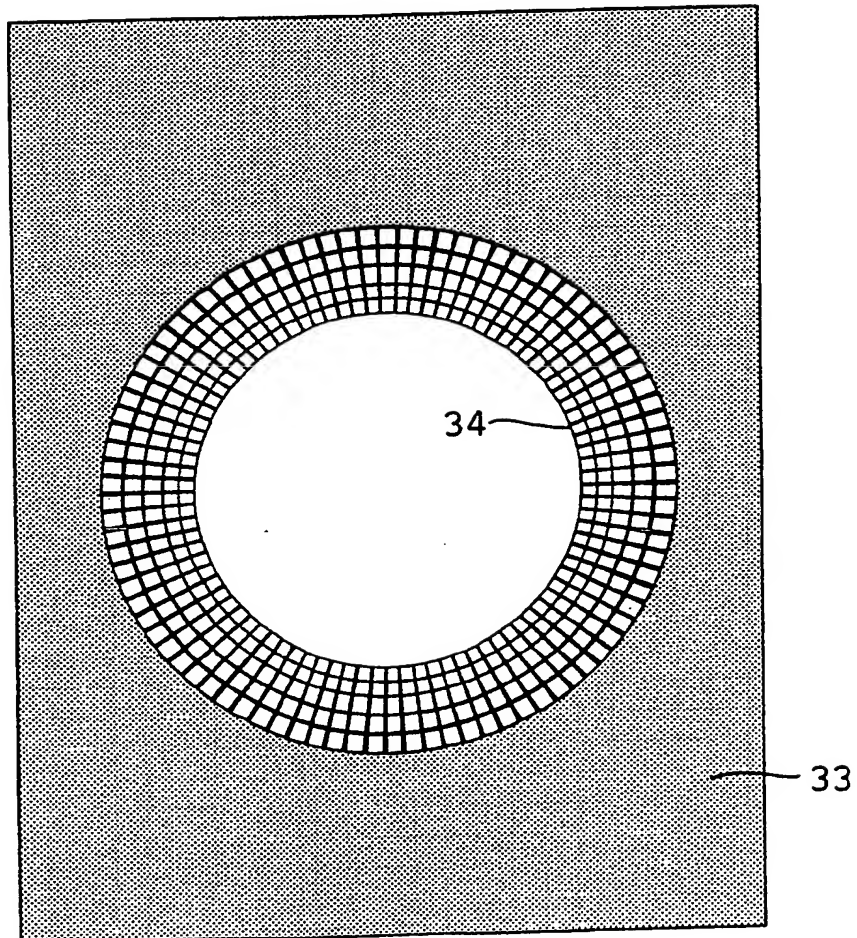


Fig.12.

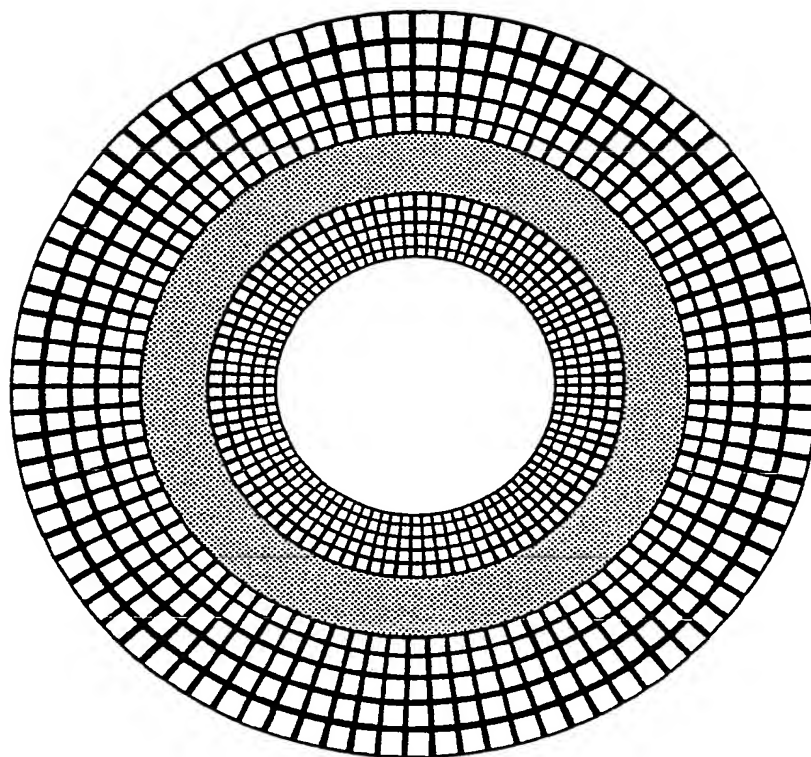


Fig.13.

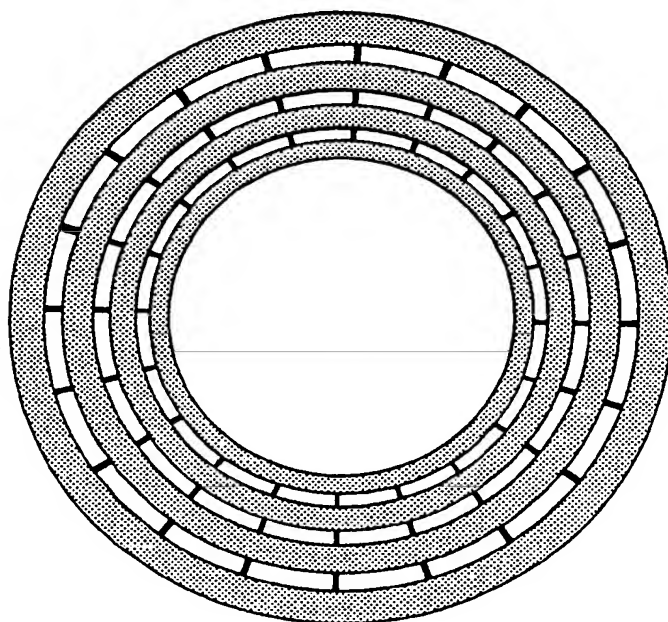


Fig.14.

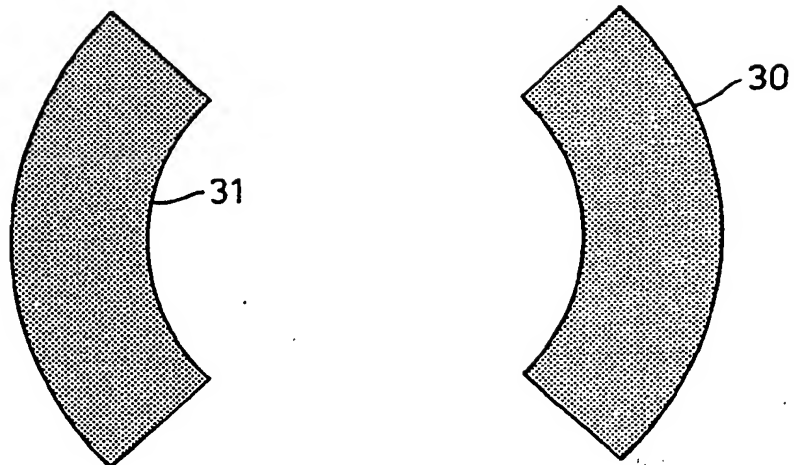


Fig.15.

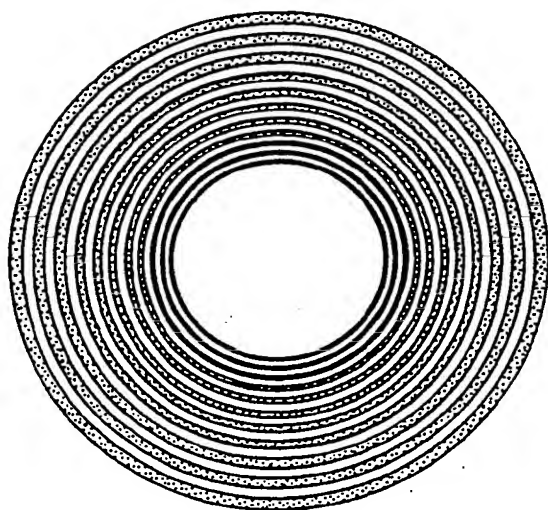
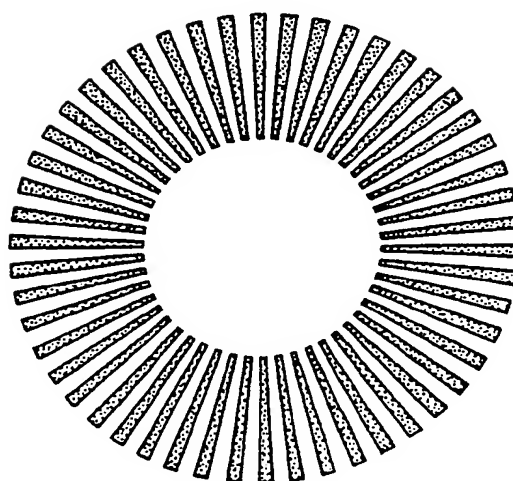


Fig.16.



ANTENNA ASSEMBLY

The invention relates to an antenna assembly and more particularly to surface wave suppression for an antenna assembly.

Antenna assemblies are known which comprise an antenna mounted on a sheet of dielectric material, like, for example, the laminar patch antenna assembly shown in our European Patent Application 93307667.1. Such antenna assemblies are particularly suited for transmission and/or reception of microwaves, and may be used in vehicles, one of the glass lights serving as the dielectric, for receiving and transmitting the 5.8 GHz signals contemplated for the electronic road roll systems currently under consideration.

It has been found that microwave antennae mounted within half a wavelength of a surface of a glass sheet excite surface waves, which are generally unwanted. These are believed to propagate in a manner akin to the transmission of light along an optical fibre, with the glass sheet acting as a waveguide. Similarly, receiving antenna located close to the glass surface can be excited by surface waves originating from some other source.

In the case of a transmitting antenna, the one or more unwanted modes of surface wave constitute a loss to the usable wave energy and, of greater concern, this lost energy can be scattered from a glass sheet at the edges

causing a radiation effect which is often detrimental to the desired radiation pattern. The proportion of energy lost in surface wave modes can reach about 50% at 5.8 GHz in automotive glass and is therefore significant to antenna efficiency and the resulting radiation pattern.

Degradation can be reduced by using thinner glass and/or lower frequencies. Experimentation has shown that surface wave problems can be kept at a level considered tolerable if the product of antenna frequency and glass thickness is less than the product of 5 millimetres x 1 GHz. In other words, problems will be expected to be significant if the thickness of a glass substrate is greater than 1/10th of a wavelength in glass. If the glass is coated with a low loss, low resistivity coating with an impedance of less than 1 Ohm per square, of the type used for a ground plane in a patch antenna, then problems will arise if the thickness is more than 1/20th of a wavelength because of the effective reflection of the substrate in the ground plane. A thickness of 1/20th of the wavelength in glass may be taken as a threshold for the onset of undesirable surface wave effects in a microstrip patch antenna.

It is an object of the present invention to provide an improved antenna assembly in which the problem of surface wave modes is reduced.

The invention provides an antenna assembly comprising an antenna mounted on a sheet of dielectric material carrying an electroconductive

layer extending around the antenna, wherein the electroconductive layer is for reducing surface wave propagation in the sheet. The surface waves are attenuated as a result of their interaction with the electroconductive layer.

The electroconductive layer may be carried on the same or a different surface of the sheet to that on which the antenna is mounted.

Surface waves may be emitted or received by the antenna in only specific directions so the electroconductive layer need not extend completely around the antenna, although it has been determined that to have the layer extending 180° or more around the antenna is preferable. Further preferably, the conductive layer extends around the antenna in spaced relation thereto, and may extend completely around thereby forming a closed loop which may be circular or rectangular in shape.

It has also been determined that a preferred resistivity for the electroconductive layer is between 5 and 2000 Ohms per square and a preferred width for the layer in the direction away from the antenna is at least 1/10th of the wavelength of the transmitted or received radiation. The width and resistivity of the layer is arranged to absorb unwanted surface wave modes before their energy can scatter from discontinuities in the sheet such as the sheet edges or another antenna mounted on the same sheet.

While a minimum width of conductive layer is necessary to achieve satisfactory absorption of surface wave modes, the maximum size will be

limited by the outer edge of the sheet or its frame or other constraints arising out of the purpose to which the dielectric material is put, such as when the sheet is for glazing. The layer may have a resistivity of 60 Ohms per square and may be at least 1 or 2 centimetres wide.

The antenna may be a laminar patch antenna.

Also preferably the antenna is a microwave antenna.

The antenna may be arranged to operate at 5.8 GHz.

It is additionally preferred for the dielectric material to be translucent, glass for example. The electroconductive layer may also be translucent.

The electroconductive layer may comprise a coating or film. When the dielectric material is glass the coating may for instance be a metal, such as silver, or a doped metal oxide, such as fluorine doped tin oxide; both of these specific examples forming translucent coatings. The coating can be applied direct to the dielectric material, say by sputtering, or to a plastics film, such as polyester, which may be adhered or trapped against the surface of the dielectric material.

When the dielectric material is translucent, the electroconductive layer may be patterned to blend visually with the translucent regions adjacent the conductive layer.

The electroconductive layer may be perforated with holes each having a maximum diameter of one half wavelength of the transmitted and/or received radiation to increase the surface impedance of the electroconductive layer.

The resistivity of the electroconductive layer may vary along a radius away from the antenna and/or a loop around the antenna.

The electroconductive layer may be provided with slots parallel with or perpendicular to a radius away from the antenna, each of the slots having a width less than a quarter wavelength of the transmitted/received radiation and preferably less than 1/10th of a wavelength. The purpose of the slots is to selectively attenuate only the TE or TM modes of the surface waves according to the pattern of slots adopted.

Two antenna may be used at the same frequency and located on the same dielectric material. The electroconductive layer, or parts of that layer, may then be located between the two antenna locations. The area located between the two antenna in such a case has an extent transverse to the axis between the two antennae of more than half a wavelength.

The invention further provides a sheet of translucent dielectric material for mounting an antenna, which sheet carries an electroconductive layer extending around the antenna mounting location, wherein the electroconductive layer is for reducing surface wave propagation in the sheet.

Some embodiments of the invention will now be described by way of examples and with reference to the accompanying drawings in which:

Figure 1 is a plan view of an antenna assembly in accordance with the present invention;

Figure 2 is a cross section through the embodiment shown in Figure 1;

Figure 3 is a similar cross section to figure 2 through a different embodiment of an antenna assembly according to the invention;

Figure 4 is another cross section through yet a further embodiment of an antenna assembly according to the invention;

Figure 5 is a perspective view of a sheet of dielectric material and electroconductive layer carried thereon of another embodiment of an antenna assembly according to the invention;

Figures 6, 7, 8 and 9 are polar diagrams indicating the radiation patterns achieved with different forms of antenna assembly according to the invention; and

Figures 10 to 16 show alternative patterns of electroconductive layer which may be used in accordance with the embodiments of Figures 1 to 5.

The preferred examples described show the use of laminar microstrip patch antennae mounted on automotive glass, such as a vehicle front, rear, roof or side light. It will however be understood that other antennae such as slot, cavity, dipole, horn, reflector or lens type antennae may be used.

The patch antenna forming part of the assembly shown in Figures 1 to 4 may be of the type shown in our European Patent Application 93307667.1.

The assembly shown in Figures 1 and 2 comprises a portion of a laminated vehicle windscreen 11 formed of an outer sheet of glass 12 which may for example be of 2.5 millimetres thickness, separated from an inner sheet of glass 13 by an interlayer 14 of polyvinylbutyral. The inner sheet of glass 13 may have a thickness for example of 1.5 millimetres and a laminating interlayer 14 may for example have a thickness of 0.76 millimetres. In Figure 1 the antenna is indicated generally by the reference numeral 15. Extending around the antenna 15 in spaced relationship therewith is a

closed circular ring 16 of electroconductive material coated on to the interior of the windscreen 11 by sputtering. The coating is of silver. The antenna 15 in this example consists of a rectangular radiating patch 18 between the inner glass sheet 13 and the interlayer 14, spaced from a conductive ground plane layer 19 by the inner glass sheet 13. The conductive ring 16 surrounds the antenna 15 around 360° and has a width in a radial direction away from the antenna of at least 1 centimetre. In this example the ring 16 terminates before reaching the edges of the windscreen 11. The ring has a resistivity of 60 Ohms per square. As best shown in Figure 2, the ring 16 is formed on the exposed surface of the inner glass sheet 13. The conductive ground plane 19 is also formed on that same surface centrally within the ring 16 and spaced from the ring 16. The radiating patch 18 is centrally located with respect to the ground plane 19.

In the modification shown in Figure 3, the laminated windscreen is the same as previously described and the conductive ring 16 is as previously described with reference to Figures 1 and 2. However, in this case the conducting patch 18 is formed on or attached to the inner face of glass sheet 13 and the ground plane 19 is separated from the patch 18 by a layer of porous plastics foam 21, serving as a dielectric.

The arrangement shown in Figure 4 is similar to that of Figure 3 except that the conducting ring 16 is now formed on the outer face of the upper sheet of

glass 12 while the patch antenna is still located on the inner face of sheet 13.

A further embodiment is shown in Figure 5 in which a sheet of dielectric material 24 in the form of a laminated glass panel, made up of two 3 millimetre glass sheets separated by a polyvinylbutyral interlayer 0.76 millimetres thick, has a central antenna mounting location 25 for receiving an antenna of any one of the types referred to above. Surrounding the mounting location 25 and spaced therefrom is a looped electroconducting layer 26. In this case the loop 26 is rectangular and is symmetrically positioned around the antenna mounting location 25. The width of the conductive layer 26 in a direction away from the antenna is 2 centimetres.

Figures 6 to 9 show typical radiation patterns from a patch antenna lying in the 0 to 180° horizontal direction with the antenna beam directed in the 90° vertical direction. Each plot is normalised so that the peak radiation value is 0 dB. For these particular examples the glass laminate used was a laminate made from 1.5 millimetre and 2.5 millimetre thicknesses of glass and a patch antenna was adhered to the 1.5 millimetre thick glass and an electroconductive film of silver supported on polyester film was applied to the 2.5 millimetre glass. Figure 6 shows a radiation pattern of a typical patch antenna away from any overlying dielectric area which would distort its pattern. The general shape and amplitude of this radiation pattern is required to be maintained when the patch antenna is required to be

maintained when the patch antenna is redesigned and adhered to an overlying glass sheet. Figure 7 shows the radiation from a patch antenna mounted against the 1.5 millimetre outer glass surface of a laminate. The antenna was positioned close to the centre of the glass sheet and the radiation pattern can be seen to have split into lobes and the gain in the forward beam direction diminished. This is due to surface waves. Adding a surrounding loop of electroconductive layer of resistivity 70 Ohms per square and width 8 centimetres returns the radiation pattern to a more desirable shape and restores the gain in the forward direction as shown in Figure 8. A similar arrangement using an electroconductive border of only 2 centimetres width is shown in Figure 9 and this again restores the radiation pattern to that required.

Some antenna generate surface waves in the dielectric material on which they are mounted in preferred directions only. It is therefore possible to omit angular sectors on the conductive ring 16 or 26 in directions relative to the antenna where little surface wave entry exists. Figure 14 shows such an arrangement where two spaced sectors 30 and 31 of the conductive ring surround opposite sides of the antenna location. In this example not more than half of the 360° is omitted.

Visual blending of a visible resistive ring into a translucent area of the dielectric material surrounding it may be achieved by a pattern of the type shown in Figure 10.

The film or coating may have a resistivity less than the desirable impedance for surface wave attenuation. A resistivity or impedance increase may be achieved by using a pattern of the type shown in Figure 11. In this case the outer coating or film 33 may be applied primarily for thermal or optical reasons and the chequered pattern forming the ring 34 where regions are coated and uncoated alternatively will provide an additional function having the required resistivity to absorb surface waves.

Figure 12 shows an arrangement in which the resistivity of the ring is varied at different radii in order to alter surface wave absorption performance.

Figure 13 shows an arrangement in which the resistivity of the ring is varied both radially and along loops around the antenna.

The surface waves will exist in both TE and TM modes. TM modes are excited by a magnetic field parallel to the surface whereas TE modes are excited by corresponding electric fields, perpendicular to the surface.

It may be desirable in some embodiments to attenuate only TM or only TE modes. This can be achieved by using the ring structures of Figures 15 and 16. The structure of Figure 15 shows a ring cut with circular slots for TE mode suppression and Figure 16 shows a ring cut with radial slots for TM

mode suppression. The slot width in both cases should be less than a quarter wavelength and preferably less than 1/10th wavelength.

The invention is not limited to the details of the foregoing examples.

CLAIMS:

1. An antenna assembly comprising an antenna mounted on a sheet of dielectric material carrying an electroconductive layer extending around the antenna, wherein the electroconductive layer is for reducing wave propagation in the sheet.
2. An antenna assembly according to claim 1 wherein the electroconductive layer extends at least 180° around the antenna.
3. An antenna assembly according to claim 1 or claim 2 wherein the electroconductive layer has a resistivity of between 5 and 2000 Ohms per square.
4. An antenna assembly according to any one of claims 1 to 3 in which the resistivity of the electroconductive layer is about 60 Ohms per square.
5. An antenna assembly according to any of claims 1 to 4 wherein the width of the electroconductive layer in a direction away from the antenna is at least 1/10th of the wavelength of the radiation transmitted and/or received by the antenna.

6. An antenna assembly according to any of claims 1 to 5 in which the said width of the electroconductive layer is at least 1 centimetre.
7. An antenna assembly according to any of claims 1 to 6 in which the said width of the electroconductive layer is at least 2 centimetres.
8. An antenna assembly according to any preceding claim in which the electroconductive layer extends around the antenna in spaced relation to the periphery of the antenna.
9. An antenna assembly according to claim 8 in which the electroconductive layer forms a closed loop around the antenna.
10. An antenna assembly according to claim 8 or claim 9 in which the electroconductive layer is circular in shape.
11. An antenna assembly according to claim 8 or claim 9 in which the electroconductive layer is rectangular in shape.
12. An antenna assembly according to any preceding claim in which said electroconductive layer extends to an outer edge of the sheet of dielectric material.

13. An antenna assembly according to any of the preceding claims in which the antenna is a laminar patch antenna.
14. An antenna assembly according to any one of the preceding claims in which the antenna is a microwave antenna.
15. An antenna assembly according to claim 13 or claim 14 in which the antenna is arranged to operate at 5.8 GHz.
16. An antenna assembly according to any one of the preceding claims wherein the sheet of dielectric material is translucent.
17. An antenna assembly according to claim 16 wherein the sheet of dielectric material is glass.
18. An antenna assembly according to claim 17 wherein the said glass is laminated.
19. An antenna assembly according to any one of the preceding claims wherein the electroconductive layer is translucent.
20. An antenna assembly according to any one of the preceding claims wherein the electroconductive layer comprises a coating or film.

21. An antenna assembly according to any of claims 16 to 20 wherein the conductive layer is patterned to blend visually with translucent regions of the sheet of dielectric material adjacent the electroconductive layer.
22. An antenna assembly according to any one of the preceding claims wherein the conductive layer is perforated with holes each having a maximum diameter of one half of the wavelength of the radiation transmitted and/or received by the antenna to increase the surface impedance of the electroconductive layer.
23. An antenna assembly according to any one of the preceding claims wherein the resistivity of the electroconductive layer varies along a radius away from the antenna and/or a loop around the antenna.
24. An antenna assembly according to any one of the preceding claims in which the electroconductive layer is provided with slots parallel or perpendicular to a radius away from the antenna, each of the slots having a width less than a quarter wavelength of the radiation transmitted and/or received by the antenna.
25. An antenna assembly as claimed in any one of the preceding claims including at least two antennae mounted on the sheet of dielectric material, the electroconductive layer having a region on an axis

between said two antennae with a minimum dimension transverse to the axis of one half wavelength.

26. A sheet of translucent dielectric material for mounting an antenna, which sheet carries an electroconductive coating extending around the antenna mounting location for reducing surface wave propagation in the sheet.
27. An antenna assembly for automotive glass which antenna assembly is substantially as hereinbefore described with reference to any one of Figures 1, 2, 3, 4 or 5.
28. An antenna assembly as claimed in claim 7 incorporating a modified electroconductive layer as illustrated in any of Figures 10 to 16.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
GB 9421712.2

Relevant Technical Fields

- (i) UK Cl (Ed.N) H1Q (QJA, QKA, QKN)
(ii) Int Cl (Ed.6) H01Q (1/12, 1/32, 1/38, 1/52, 9/04)

Search Examiner
J A WATT

Date of completion of Search
30 AUGUST 1995

Databases (see below)

- (i) UK Patent Office collections of GB, EP, WO and US patent specifications.

Documents considered relevant following a search in respect of Claims :-
1-25, 27 AND 28

(ii)

Categories of documents

- X: Document indicating lack of novelty or of inventive step. P: Document published on or after the declared priority date but before the filing date of the present application.
Y: Document indicating lack of inventive step if combined with one or more other documents of the same category. E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A: Document indicating technological background and/or state of the art. &: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X,Y	GB 1594559 A	(BALL CORPORATION) Figure 3 and lines 30-59, page 3	X: 1, 2, 8, 9, 11, 13 Y: 19, 20 at least
X	WO 93/23890 A1	(FUBA HANS KOLBE) Figures 1-11	1, 2, 8, 9, 11 and 16-20 at least
Y	US 5178722 A	(TOYO BOSSAN) Figure 1 and lines 9-12, column 1 and 1-8, column 4	19, 20 at least
X,Y	US 4291312 A	(US NAVY) Figures 1-32 and line 57, column 1 to line 54, column 2	X: 1, 2, 8, 9, 11, 13 Y: 19, 20 at least

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